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COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

January 30, 1995

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re ET Docket No. 94-124
RM-8308

In the Matter of Amendments of
Parts 2 and 15 of the Commission's
Rules to Permit Use of Radio
Frequencies Above 40 GHz for
New Radio Applications

Dear Ms. Searcy:

Transmitted herewith by the National Academy of Sciences, through the Committee on Radio Frequencies of the National Research Council, are an original and nine (9) copies of its comments in the above-referenced proceedings.

If additional information is required concerning this matter, please communicate with this office.

Sincerely yours,

Robert L. Riemer

Robert L. Riemer
Senior Program Officer

Enclosure

cc: Members of CORF
Mr. Paul J. Feldman
Mr. Richard Gould

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FEDERAL COMMUNICATIONS COMMISSION
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Use of Radio Frequencies Above 40 GHz	)	RM-8308
for New Radio Applications	)	

COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

The National Academy of Science, through the National Research Council's Committee on Radio Frequencies ("CORF"), hereby submits its comments in response to the Commission's Notice of Proposed Rule Making in the above-captioned proceeding. CORF represents the interests of the Radio Astronomy Service, the Earth Exploration Satellite Service, the Space Research Service, and other users of the radio spectrum engaged in scientific research. The radio astronomy and remote sensing communities have pioneered the use of the spectrum above 40 GHz, and have produced a number of scientific breakthroughs in this spectral region. In these comments, CORF seeks to ensure continued protected access of the scientific community to this extremely important portion of the spectrum, while at the same time recognizing that it can be opened up to commercial development.

I. The Importance of Research In Bands Above 40 GHz.

The Radio Astronomy, Remote Sensing, and Space Research communities have great interest in the frequency range above 40 GHz. Radio emissions of interest to scientists include a broad continuum that covers the whole range of frequencies, together with a large number of specific atomic and molecular spectral lines, each of which is confined to a relatively narrow frequency range. In the last 30 years, radio astronomy studies have demonstrated the presence of ever more complex molecules in interstellar space. These discoveries are one of the most fascinating and puzzling developments in the field. Many natural emissions from these atoms and molecules, both from within our galaxy, and in numerous other galaxies, occur above 40 GHz. In fact, the frequency range of interest to radio astronomy, as well as remote sensing, now extends to well above 500 GHz.

The continuum bands above 40 GHz now allocated to Radio Astronomy and to the Earth Exploration Satellite Service are particularly useful to researchers because they have large enough bandwidths to take full advantage of modern receiver technology. Furthermore, these bands are situated in regions of the spectrum where atmospheric windows exist.

The complexity of the largest molecules discovered in space already exceeds that of simple amino acids, and detection of still more complex molecules is anticipated. The identification of these complex molecules can be made only by the detection of radio lines. About 30 molecular lines in the 40-300 GHz range are listed in the Recommendation ITU-R RA. 314-7, as being of the greatest importance to radioastronomy (furthermore, important information such as supporting evidence has been derived from many other lines, not listed as being of the greatest astrophysical importance). Unfortunately, not all of these lines fall within established protected bands allocated to the passive services. The search for astrophysically important lines is continuing, and the potential for the discovery of such lines is indicated by the fact that the second strongest line (of the methanol molecule) was discovered only in 1991.[1]

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[1]It also should be noted that because of the motion of the sources and the expansion of the universe, many of the spectral lines of great interest to radio astronomy are Doppler shifted over wide frequency ranges. For example, the 115 GHz carbon monoxide (CO) line, one of the most important interstellar molecular lines used to trace the distribution of gas in spiral galaxies, has been discovered recently in an external galaxy, enormously redshifted to 36 GHz. Similarly, many of the allocations intended to protect observation of specific spectral lines in our own galaxy also serve to protect the high-red-shifted measurements from more distant sources.

II. Technological Contributions of Radio Astronomy and Remote Sensing to Use of the Spectrum Above 40 GHz.

As CORF noted above, radio astronomers and the remote sensing community have pioneered the use of spectrum above 40 GHz. Among the most significant contributions, CORF notes:

-The development of low noise (10 K) receivers from a few MHz to 1000 GHz;

-The study of body thermography, using millimeter wave techniques (at 45 GHz); and

-The measurement of the temperature of the Earth's atmosphere, its surface properties, and the distribution of water vapor, cloud water, precipitation, upper-atmosphere ozone, and impurities such as carbon monoxide, by passive remote sensing techniques.

Radio astronomers continue to do pioneering work which may lead to important commercial applications, today and in the future. For example, the Caltech Submillimeter Observatory has developed receivers which routinely make observations at frequencies as high as 480 GHz. These observations provide access to the very important spectral line of neutral carbon in the interstellar medium. Two millimeter wave interferometers are currently in operation in the U.S., studying the distribution of matter and physical phenomena in star-forming regions. A large millimeter telescope is being built by U.S. and Mexican scientists, and the National Radio Astronomy Observatory is developing a millimeter-wave array, expected to be the leading instrument in the field by the turn of the century. These facilities will be used for a wide range of galactic and extra-galactic studies.

Similarly, meteorologists are building instruments to determine atmospheric temperatures at altitudes up to 80 kilometers in the atmosphere. These measurements promise to substantially improve both short and long-range forecast capabilities.

These developments show the enormous vitality of the research performed by the U.S. scientific community in the spectrum above 40 GHz. In fact, scientists have substantial contributions to make to, and are interested in, the proposed commercial development of the spectrum. At the same time, however, CORF believes that such development can and should be accomplished while the interests of the scientific community in the spectrum are protected.

III. General Protection Required for Research Above 40 GHz.

The harmful interference levels for the radio bands allocated to the Radio Astronomy Service above 40 GHz have been computed and tabulated in ITU-R RA.769. It is important to note that the levels above 40 GHz are typically about 1000 times (30 dB) less stringent than those at lower frequencies. This difference results from the reduced size of the effective receiving aperture for interference, taken to be that of an isotropic antenna (since, for a fixed gain, the aperture is proportional to the inverse square of the frequency). Considering this inherent antenna characteristic, together with propagation characteristics at millimeter wavelengths, effective protection of scientific use of the frequencies above 40 GHz need not be in conflict with commercial development of the spectrum, provided good engineering practice is followed.

The most critical requirement for radio astronomers is for protection from transmitters on satellites and aircraft, since terrain does not shield observatories from such emissions. The primary requirement in such cases is protection from spurious and out-of-band radiation. It is particularly important that transmissions from these sources be strictly limited to the "necessary bandwidth". For direct sequence spread spectrum and other digital modulation techniques, this requires substantial filtering or other band-limiting techniques.

The primary concern for radio astronomers regarding terrestrial transmitters is the proximity of such transmitters to remote observatory sites. Given the small number and relatively isolated locations of such sites, together with the propagation characteristics at millimeter wavelengths and the proposed low power of both licensed and unlicensed transmitters above 40 GHz, protection zones around the sites represent an attractive method to limit interference without significant impact on commercial development above 40 GHz. The functional size of such a protection zone at a particular frequency would be determined using the specific screening characteristics of the site. Such protection zones need be of only modest size, due to the propagation properties of millimeter wavelength radiation. CORF has begun the process of calculating the parameters of proposed protection zones, and will supply the results to the Commission as soon as they are available.

IV. Particular Protection Needs.

CORF draws attention to the following specific instances in which there is close proximity or overlap of the proposed new commercial bands to existing allocations (or footnote protection) of passive services:

(1) As the Commission stated in note 24 of the Notice, the proposed band at 40.5-42.5 GHz is subject to footnote US211 of the Table of Allocations. The Commission properly proposes to exclude any air-to-ground uses, and states that any space-to-earth use would have to demonstrate protection of radio astronomy users. As noted below, other bands proposed in this proceeding are also subject to US211, and CORF firmly supports application of similar limitations on uses in those bands. CORF believes that such limitations will have limited impact on proposed commercial uses, but will nevertheless protect radio astronomers from some of the most potentially damaging uses. Indeed, in light of the limited burden on commercial users and the important protection to radio astronomers, CORF recommends that the Commission modify footnote US211 in this proceeding to include all of the bands listed below that are not currently set forth in that footnote.

(2) The proposed bands 47.2-47.4 GHz for vehicle radar and 47.4-48.2 GHz for licensed devices lie just below the 48.94-49.04 GHz band, which contains the lines from the CS ($J=1\rightarrow0$) molecular transition used by radio astronomers to study molecular clouds, active galactic nuclei, and starburst galaxies. Observation of spectral lines in the 48.94-49.04 GHz band is protected from space and airborne transmissions by international footnotes 904 and 905.

(3) The large 59.0-64.0 GHz band proposed for unlicensed devices falls in that part of the spectrum in which oxygen in the earth's atmosphere strongly limits propagation; as such this band is ideally suited for spectral re-use over short distances. CORF notes, however, that the bands just below and just above, at

58.2-59.0 GHz and 64.0-65.0 GHz, are allocated to the passive services.

(4) The proposed 71-72 GHz band lies close to the 72.77-72.91 GHz band, which is protected by footnote US270.

(5) The proposed 84-85 GHz band lies just below the very important 86-92 GHz band allocated to the passive research services. Services in the 84-86 GHz band are subject to footnote US211.

(6) The proposed vehicle radar band 94.7-95.7 GHz lies between the 93.07-93.27 GHz and 97.88-98.08 GHz bands used for radio astronomy spectral-line observations. See international footnotes 914 and 904, respectively.

(7) The proposed 103-104 GHz band lies just below the very important 105-116 GHz band allocated to passive research.

(8) There is direct overlap of the proposed 116-117 GHz and 122-123 GHz bands with the 116-126 GHz primary allocation to the Earth Exploration Satellite (passive) and Space Research (passive) services. These proposed bands are also currently subject to footnote US211. The proposed 126-127 GHz band lies just above a band subject to US211 protection.

(9) The proposed Vehicle Radar band at 139-140 GHz lies just below the 140.69-140.98 GHz passive research band.

(10) The proposed 152-153 GHz band lies just above the 150-151 GHz passive research band.

These instances of close proximity of the proposed commercial bands to passive research and radio astronomy bands underscore the need for protection of the passive services from unwanted emission. While some protection can come from good engineering design standards, and service rules to be created in later proceedings, the Commission has seen the wisdom of providing footnote protection in the table of allocations in the past in some of the above bands. CORF suggests that such protection be expanded (in US211) to all of the above bands not already subject to footnote protection.

V. Conclusion.

All users of the spectrum can benefit from the wider bandwidths and more ready availability of spectrum above 40 GHz, to relieve the congestion at longer wavelengths. Allocations of this spectrum can be made for valuable commercial uses that do not interfere with radio astronomy and other passive uses of the spectrum, as long as the Commission enacts certain minimum protections for passive users. These protections should not substantially burden commercial use of the proposed bands.

CORF is grateful that the Commission has, in this and prior proceedings, paid careful attention to the needs of the scientific research community. CORF looks forward to working with the Commission, in this and future proceedings, towards the enactment of rules that benefit all users.

Respectfully submitted,
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By: CW Collazo for
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President

January 30, 1995

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